NASA’s Hubble Space Telescope: Presentation to the Freedom Museum

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Hubble – Big Picture

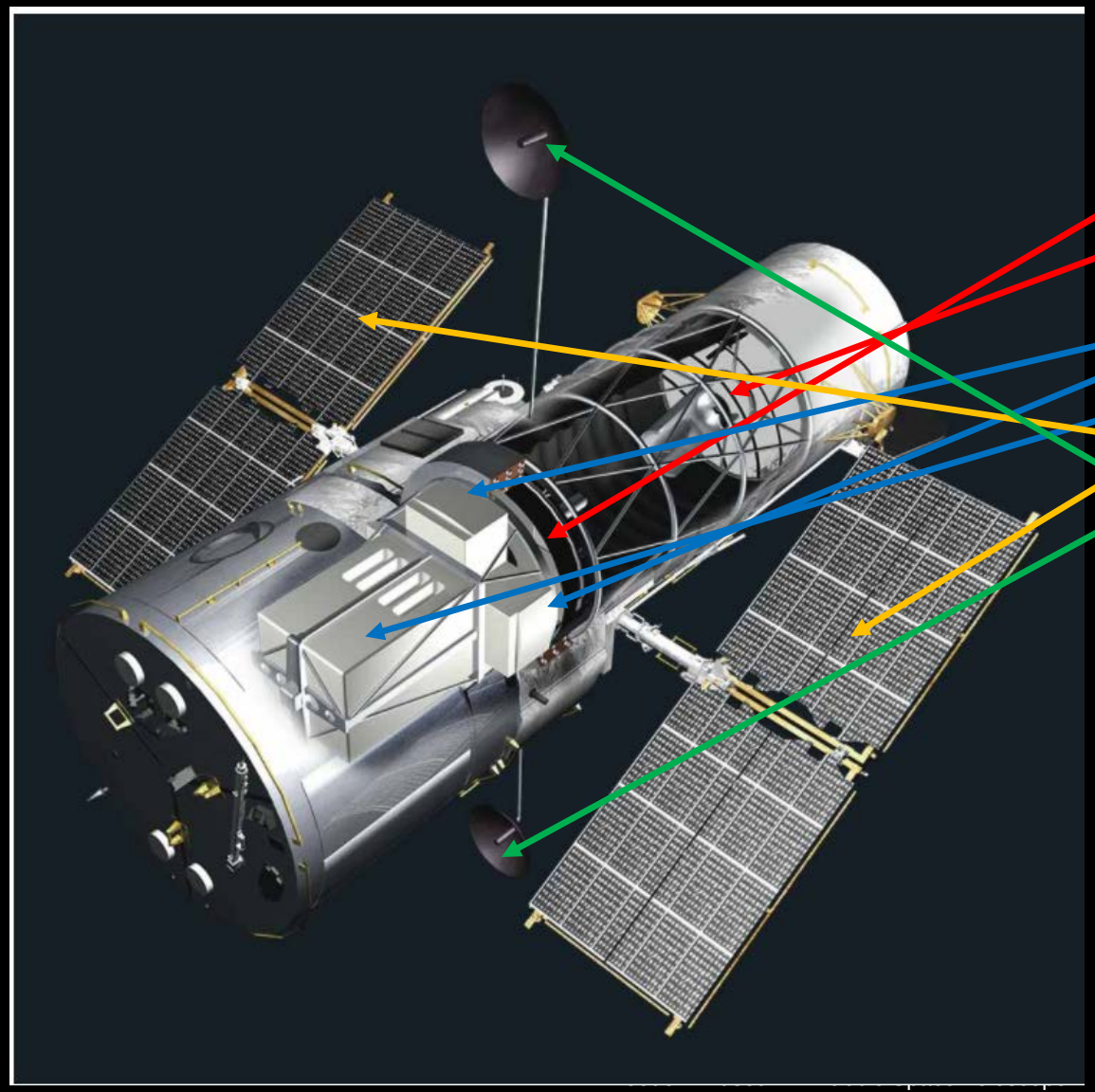
- The Hubble Space Telescope – HST – is The People's Telescope
- One of the Great Observatories, - with Compton Gamma Ray Observatory, Spitzer (InfraRed) Space Telescope, and Chandra X-Ray Observatory
- Conceived by Lyman Spitzer in 1946. After two precursor missions in 1960s, was to be a 3-meter diameter Large Space Telescope, to be serviced regularly on-orbit
  - Would have design based on Goddard's Multi-Mission Modular Spacecraft
- All funding cut in 1974, but outcry by public and astronomers led to a reduced budget, 2.4-m, joint with Europe, started 1978
- Funded by the US government through NASA, plus European Space Agency contributions (solar arrays, an instrument)
- Built under direction of NASA Marshall Space Flight Center in Huntsville, Alabama, the spacecraft by the Lockheed Company in Sunnyvale, California and Optical Telescope Assembly by Perkin Elmer in Danbury, Connecticut. Backup mirror built by Kodak (now in Smithsonian A&S)
- Launched on the Space Shuttle in 1990, still fully operational today

HST - Built and Launched

- Making the primary mirror was much more difficult, taking much more money and time than initially planned
- Servicing was controversial – trading out instruments was always planned, but other parts were deemed adequately reliable and replace-ability was de-funded.
- After the value of servicing was demonstrated NASA's Frank Cepollina; "Cepi", on the Solar Max repair mission in April 1984, STS-41-C, servicing was fully restored
  - Chronicled in the 1985 IMAX movie, "The Dream is Alive"
- Adding back of ExtraVehicular Activity (EVA) aids led by Ron Sheffield
  - Army helicopter pilot in Viet Nam, then pilot instructor
  - Continued to support servicing through SM-3B
- By 1985, HST was nearly finished; planned for Shuttle launch Oct 1986
- The Challenger Accident (/ Disaster) in Jan 1986 led to delay
- HST Launched on Discovery, STS-31, April 24, 1990
  - Crew included Charles (Charley) Bolden, later Maj. Gen. in USMC and NASA Administrator

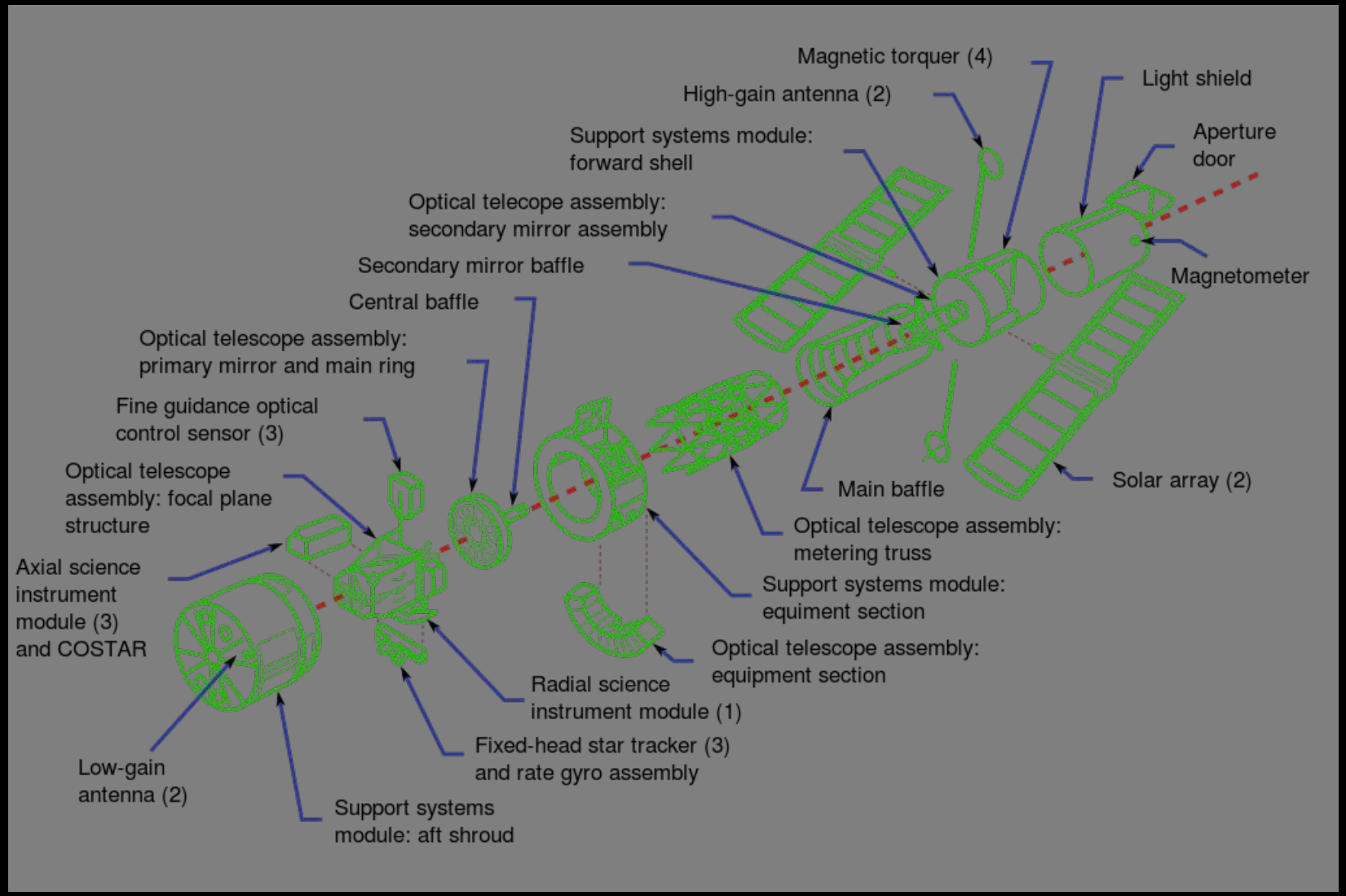
Canada

Hubble – the major parts



- Telescope
  - Primary Mirror
  - Secondary Mirror
- Aft Shroud
  - Radial Instruments (4)
  - Axial Instruments (4)
- Solar Arrays
- High Gain Antennas

Exploded View



Launch date: 24 April 1990

Launch vehicle: Space Shuttle Discovery (STS-31)

Mass: 24,000 lbs (10,886 kg)

Maximum diameter: 14 ft (4.2 m)

Length: 43 ft (13 m)

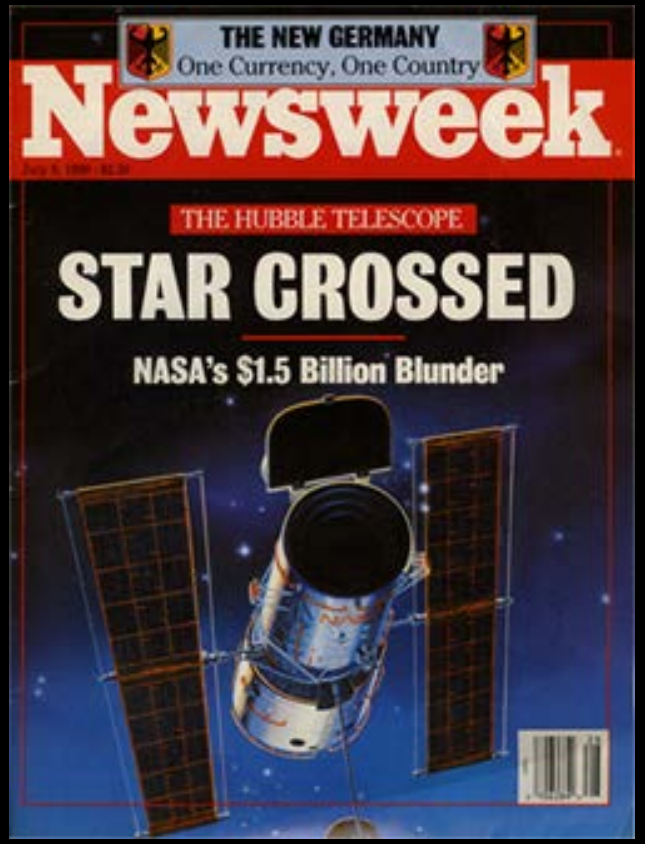
Orbit Height: 340 miles (547 km)

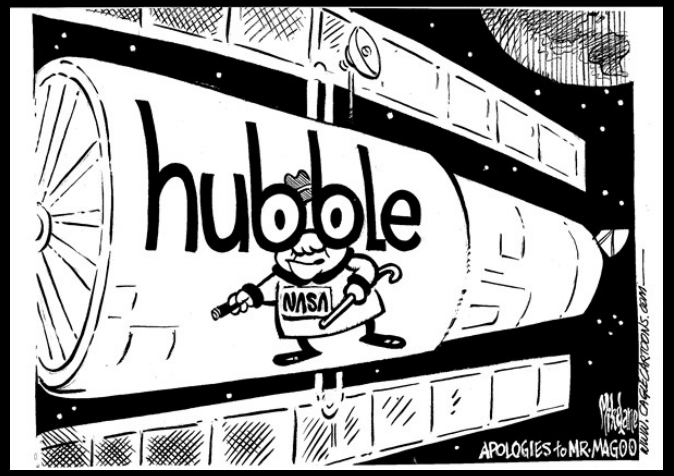
Orbit period: ~95 minutes

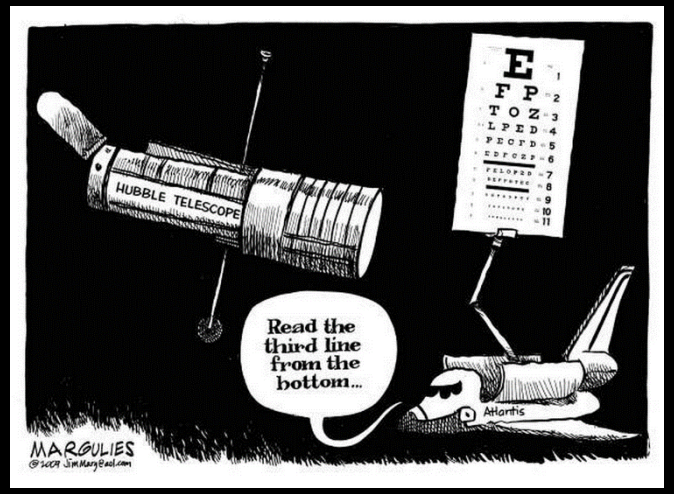
Orbit velocity: 17,000 mph (27,300 kph)

Uh-Oh!

- After launch and initial check-out, a problem emerged
- All attempts at adjusting the focusing mechanisms to optimize the position of the secondary mirror resulted in poor image quality
- A scientist at the Space Telescope Science Institute, which was responsible for planning the observations, recognized the pattern
- Found that analyzing the imagery of a point source through an algorithm that would remove a specific pattern of spherical aberration produced a point image, but with 1/100th of the light


THE NEW GERMANY
One Currency, One Country
Newsweek
THE HUBBLE TELESCOPE
STAR CROSSED
NASA's $1.5 Billion Blunder

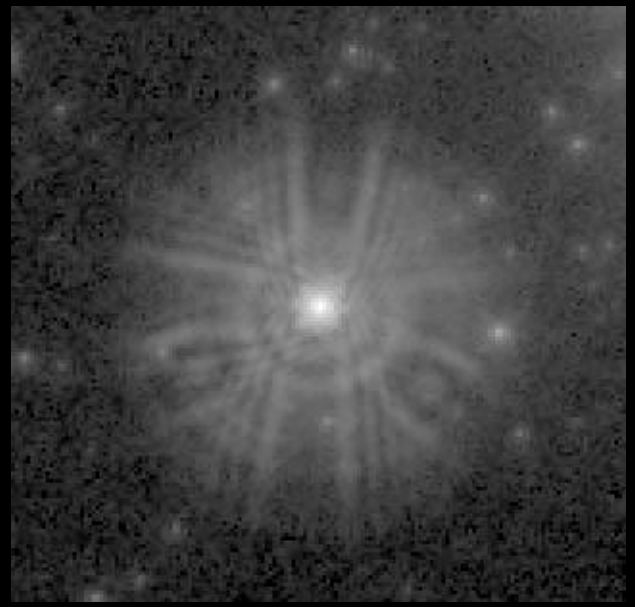

hubble
NASA
APOLOGIES to MR. MAGOO

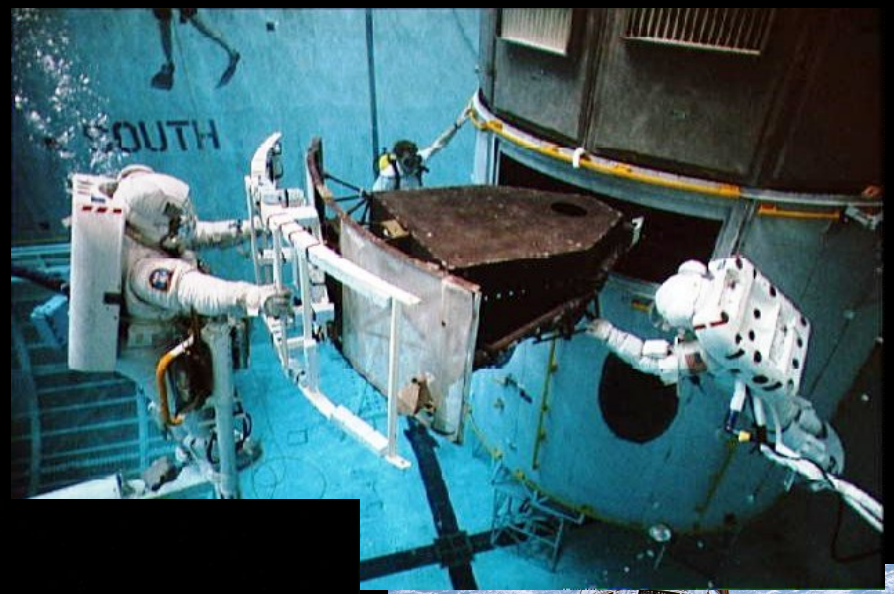

HUBBLE TELESCOPE
Read the third line from the bottom...
Atlantis
MARGULIES

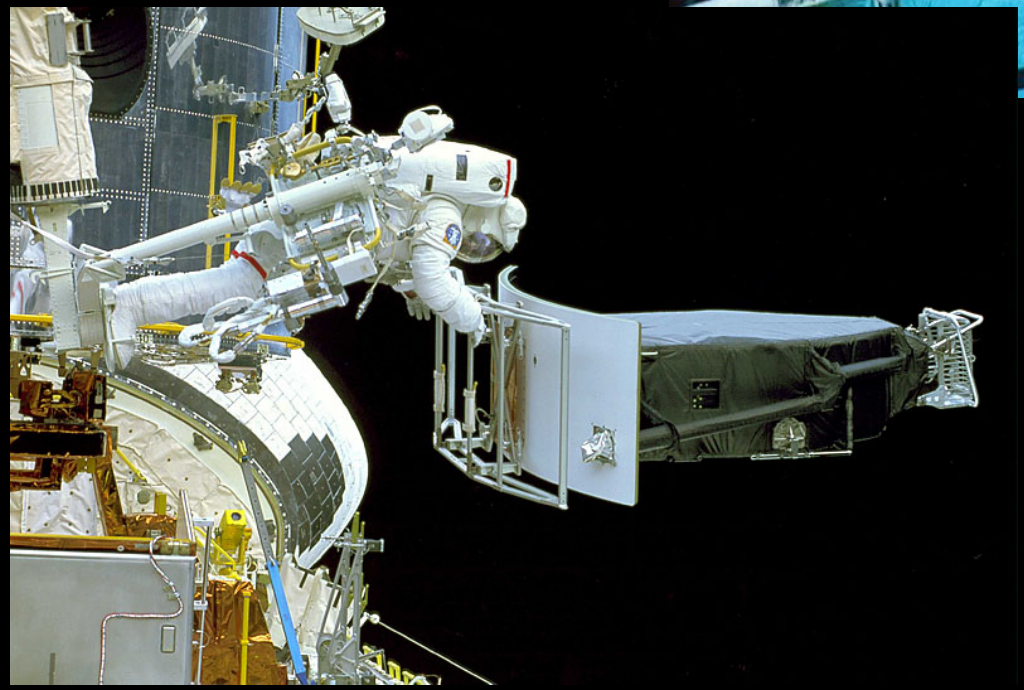
The Fix!

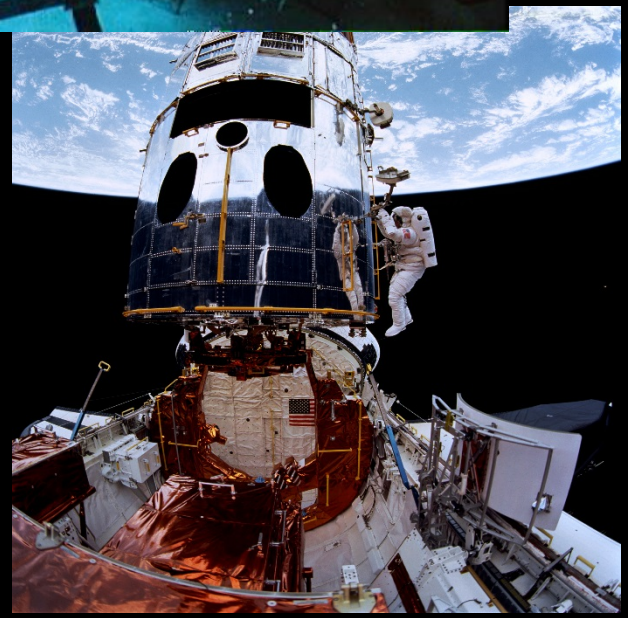
- The prescription to completely correct was known shortly after launch
- The existing Space Telescope Axial Replacement, which was intended as a substitute in case a flight instrument broke too late to be repaired, was converted into the Corrective Optics STAR, or COSTAR.
- The Wide Field Camera II was built at JPL to include a flat mirror with the inverse prescription

Point Spread Function => WF/PC-2









The Result of the Fix!

Hubble Missions

Launch!

1990

SM1

Wide Field Planetary Camera 2
COSTAR
Gyros
Solar Arrays

1993

SM2

Imaging Spectrograph
Near Infrared Camera
Fine Guidance Sensor

1997

SM3A

Gyros
Advanced Computer
Fine Guidance Sensor

1999

SM3B

Advanced Camera
Solar Arrays
Power Control Unit
NICMOS Cooling System

2002

SM4

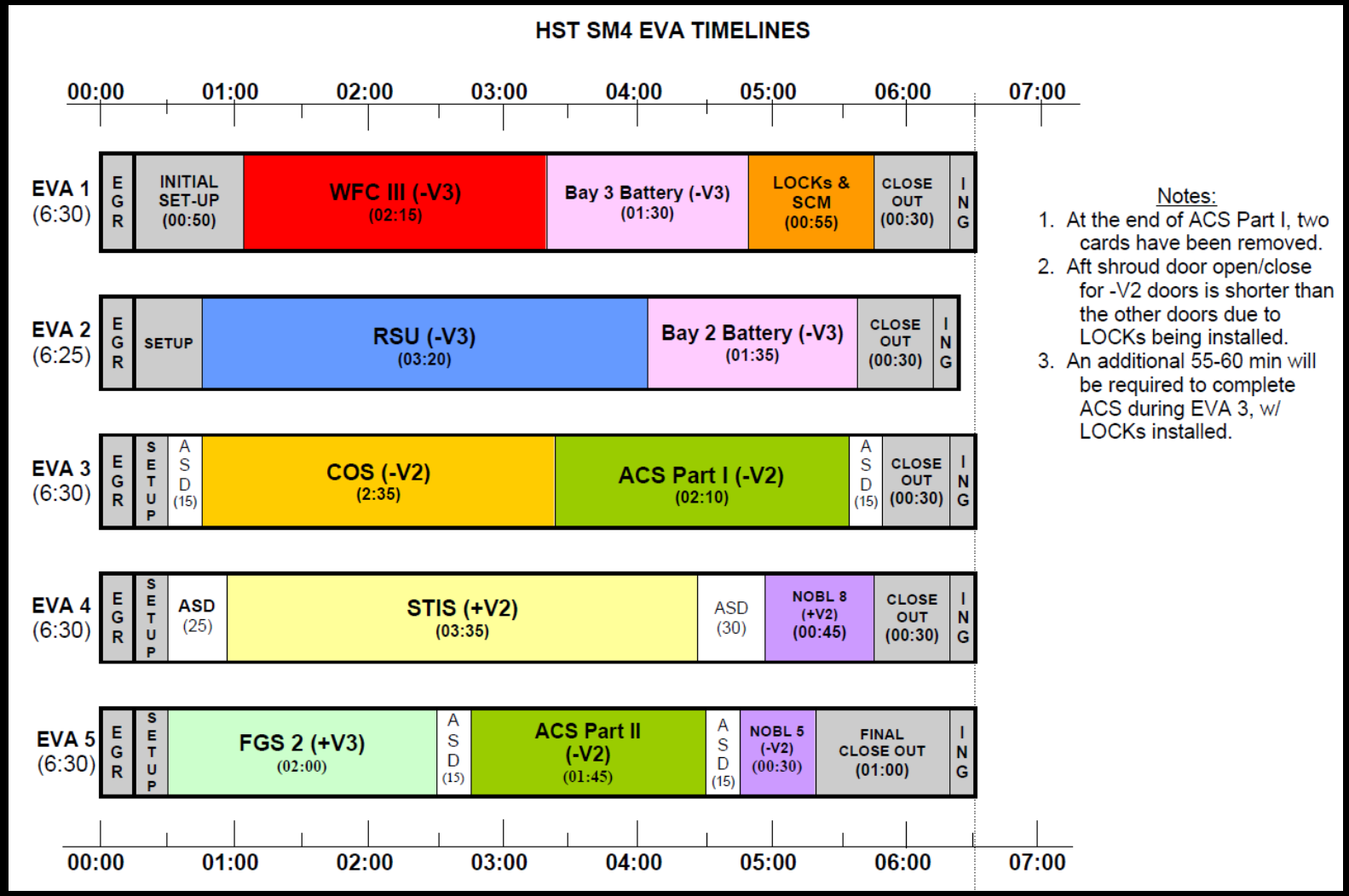
Gyros
SIC&DH
Wide Field Camera 3
Cosmic Origins Spectrograph
Batteries
Fine Guidance Sensor
STIS & ACS Repairs
New Outer Blanket Layer
Soft Capture Mechanism

2009

De-Orbit Mission

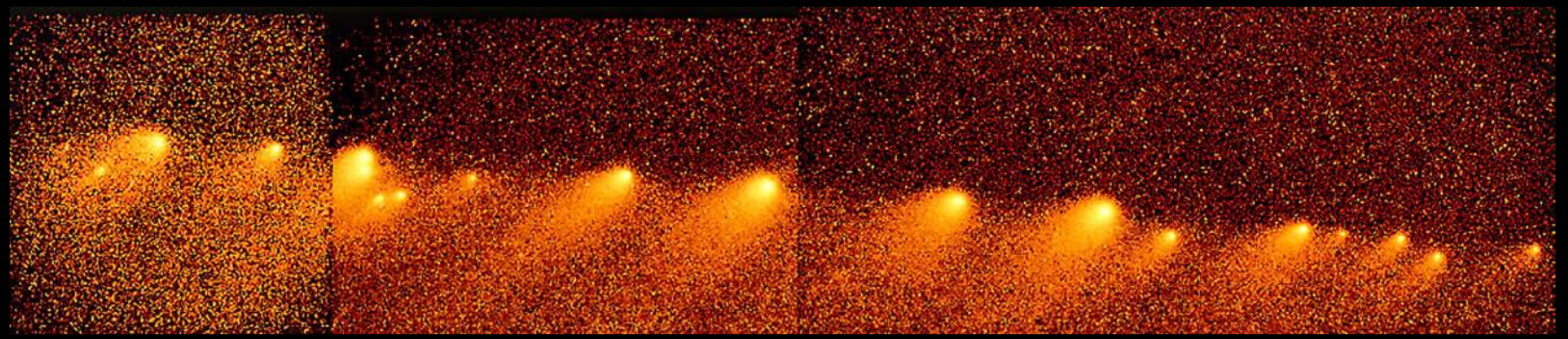
NET2020

HST Servicing Mission 4 Timeline - Plan



Notes:

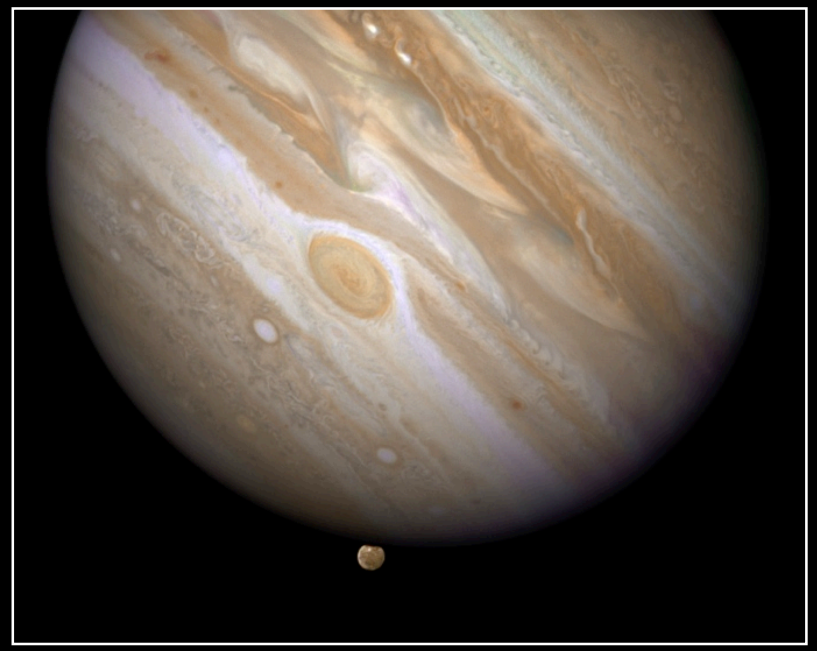
1. At the end of ACS Part I, two cards have been removed.
2. Aft shroud door open/close for -V2 doors is shorter than the other doors due to LOCKs being installed.
3. An additional 55-60 min will be required to complete ACS during EVA 3, w/ LOCKs installed.

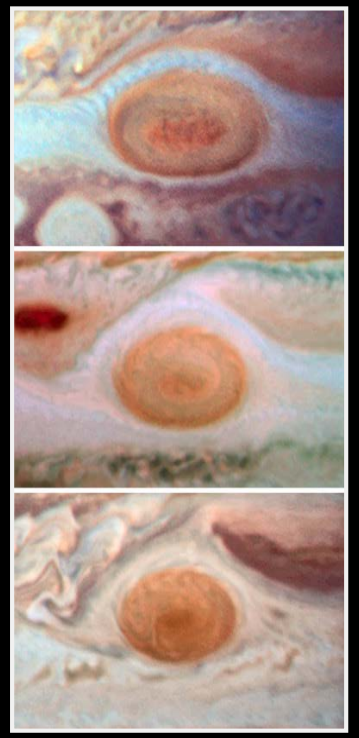


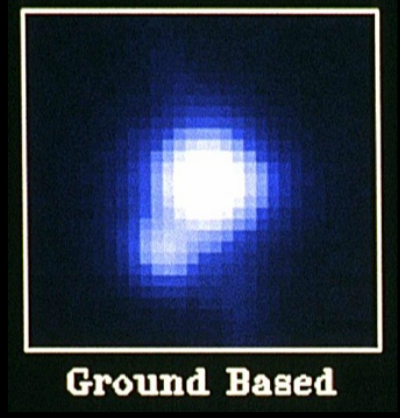
SL9 impacts July 1994

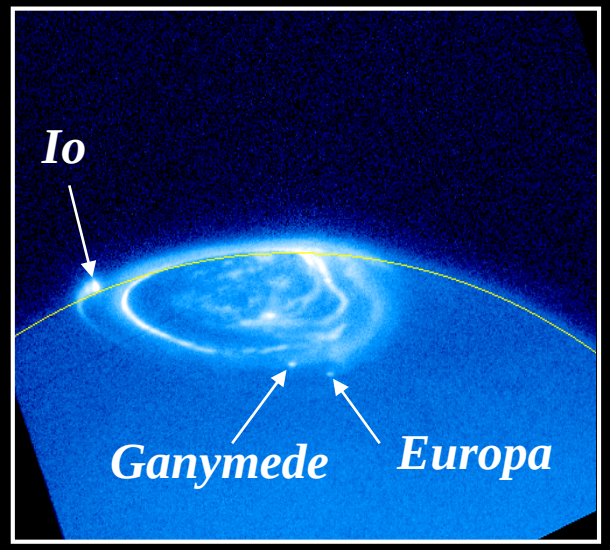
Visible Light

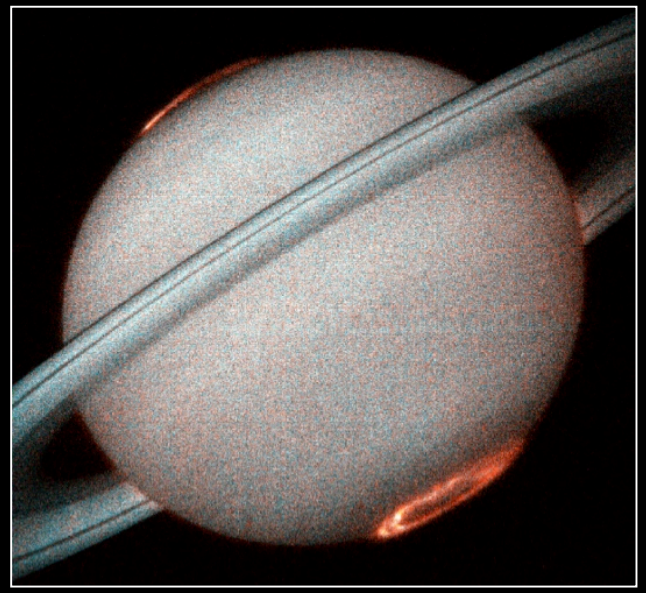
Ultraviolet Light

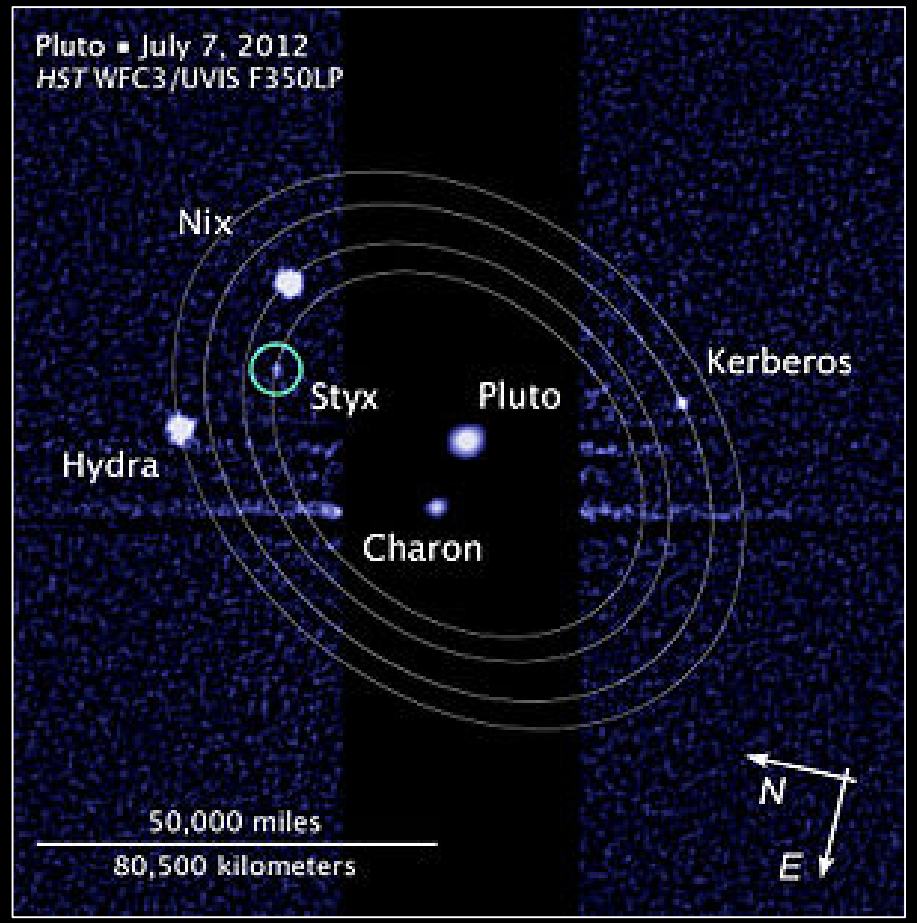


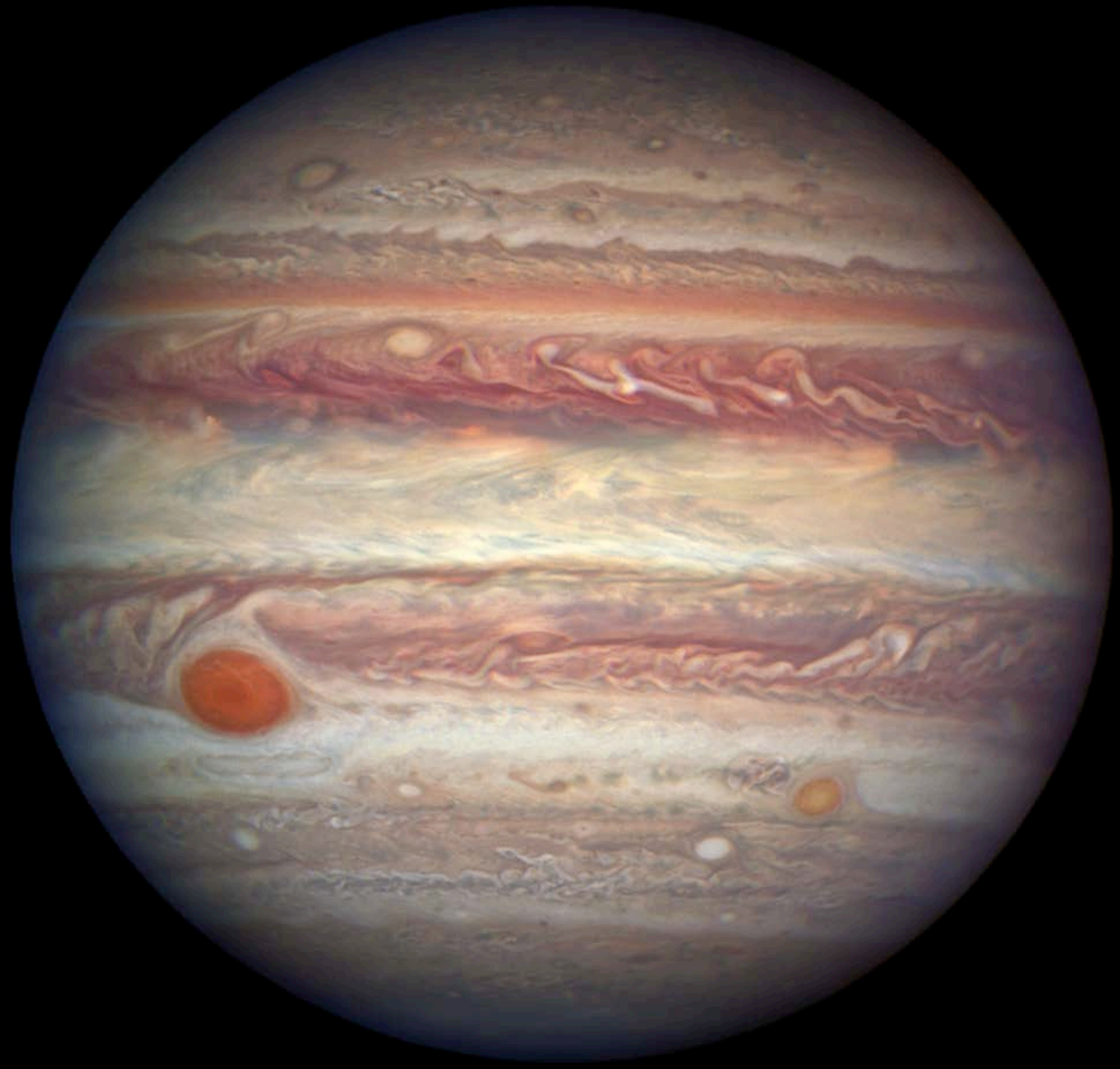



Ground Based

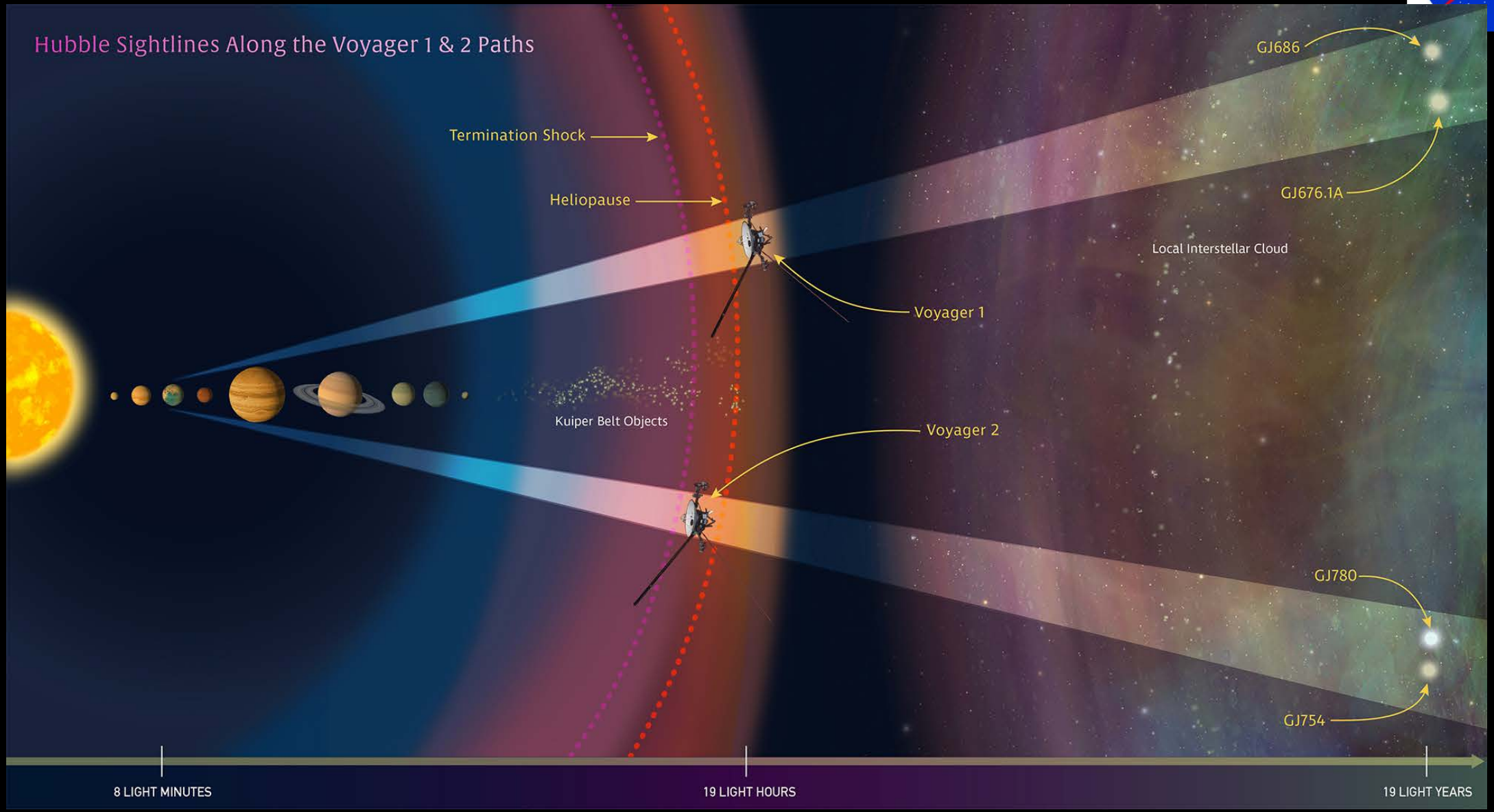

Io
Ganymede
Europa



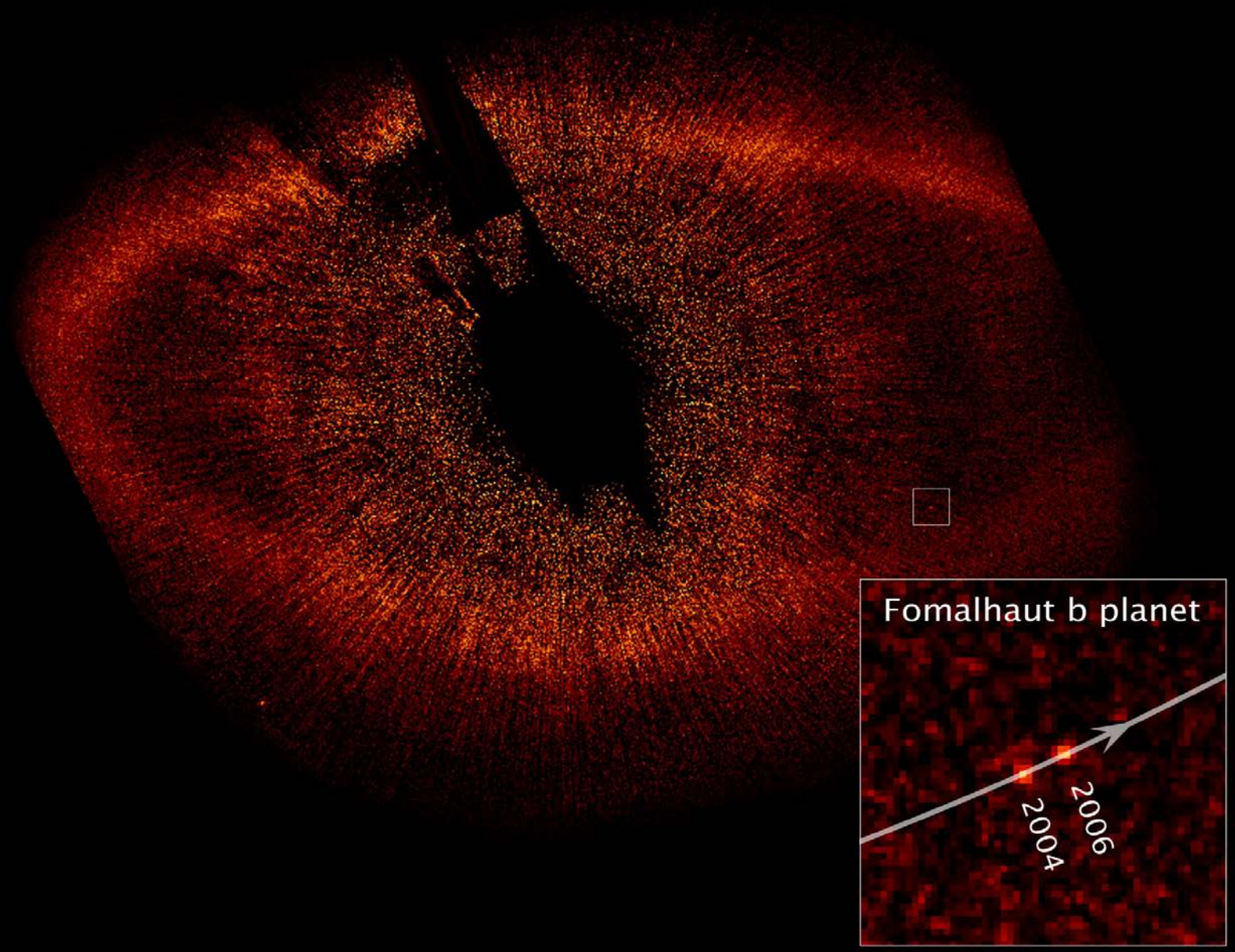

Pluto • July 7, 2012
HST WFC3/UVIS F350LP
Nix
Styx
Pluto
Kerberos
Hydra
Charon
50,000 miles
80,500 kilometers
N
E



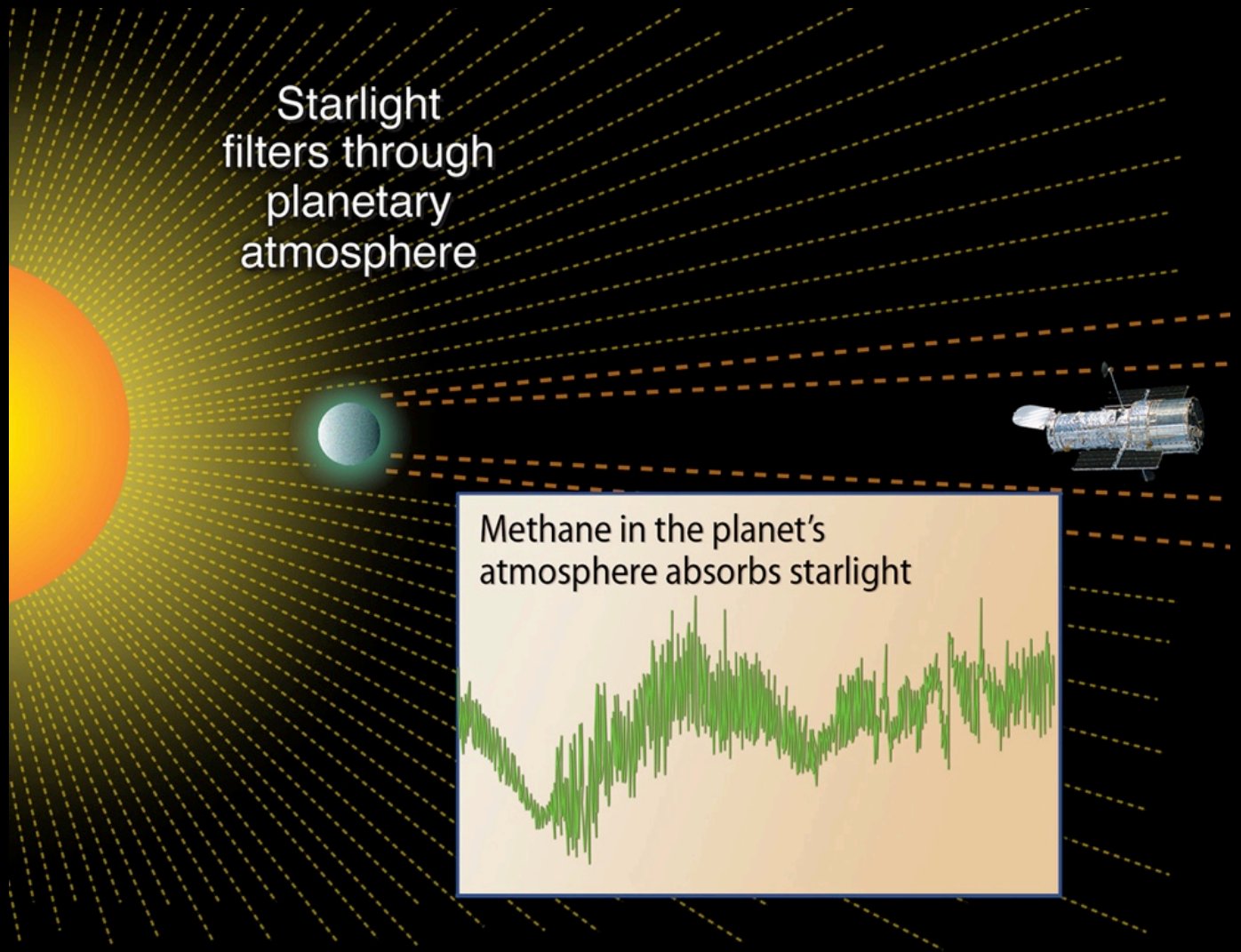
Examining the Outward Path of V'Ger Candidates...

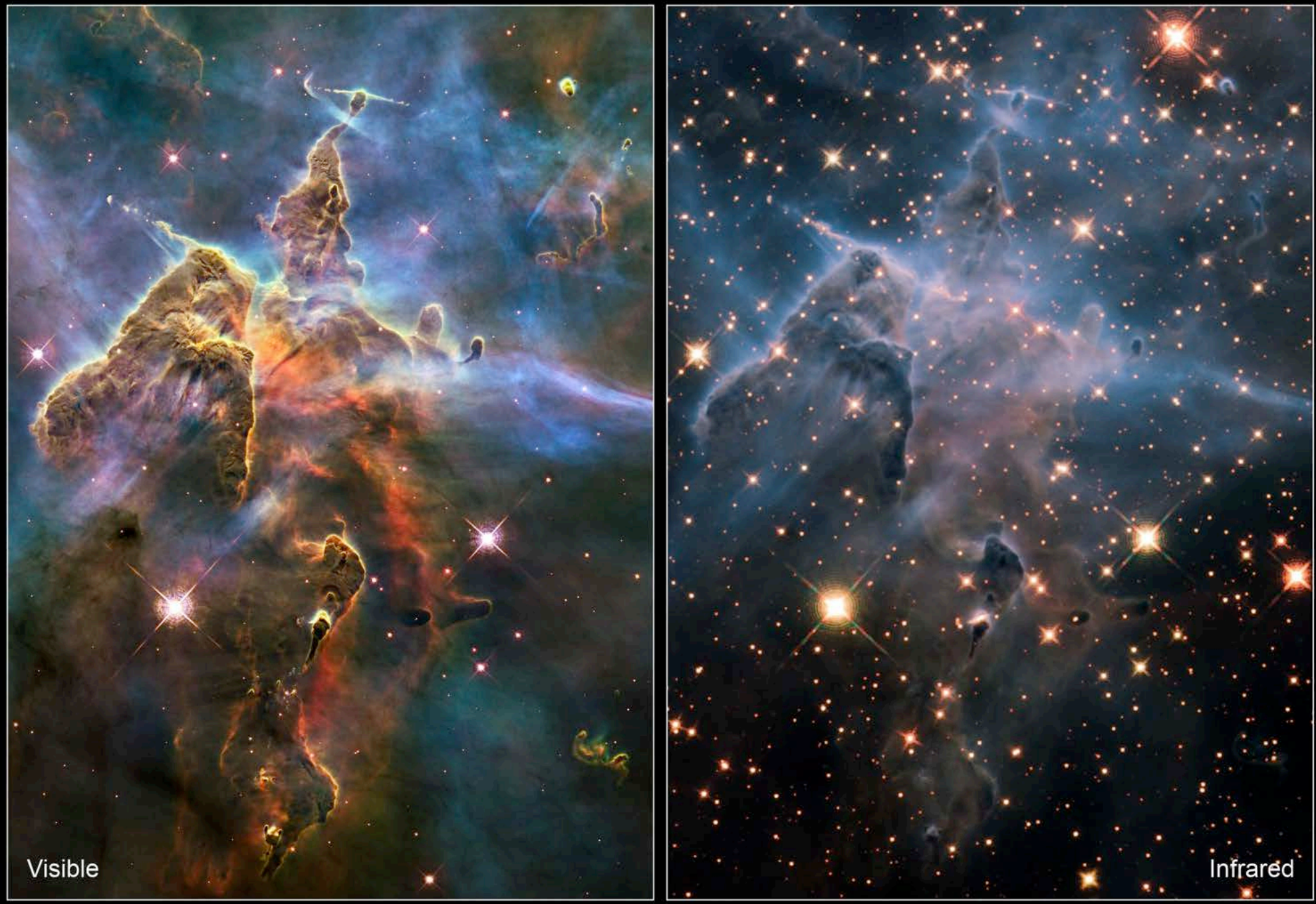


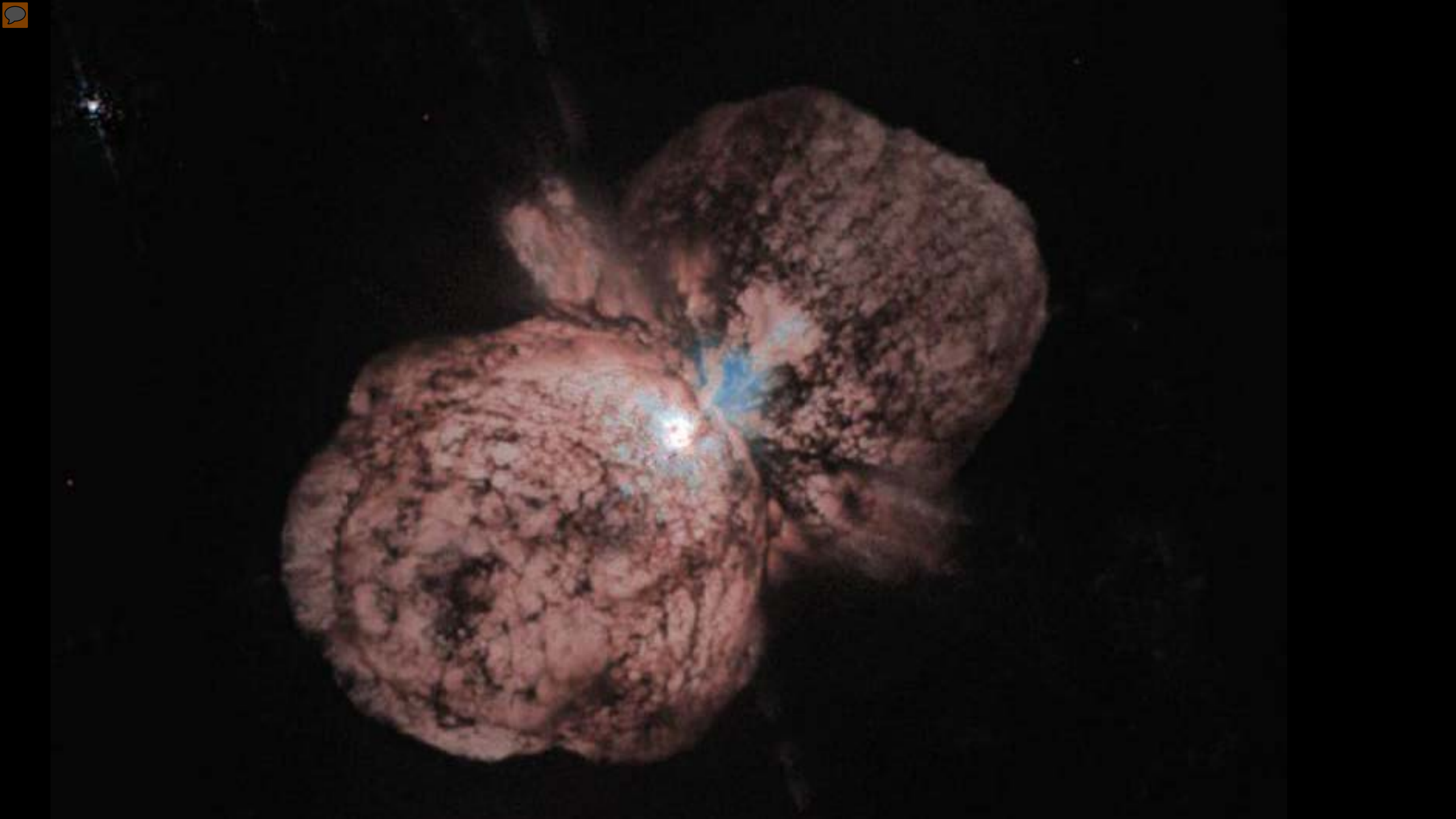
Fomalhaut b –a planet in a debris disk around a nearby star

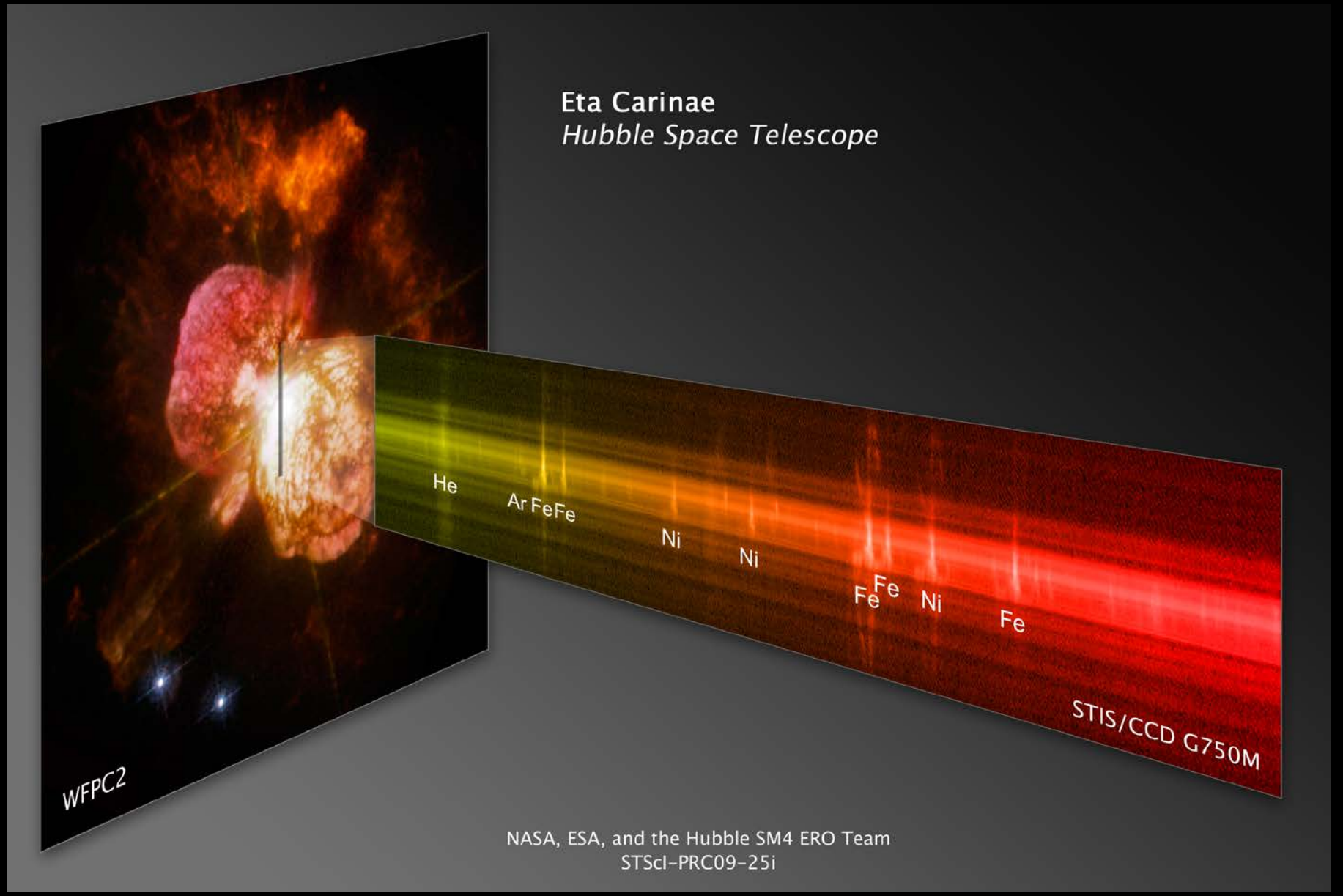


HD 18733b – Methane in an exoplanet atmosphere




Visible
Infrared




Eta Carinae
Hubble Space Telescope
WFPC2
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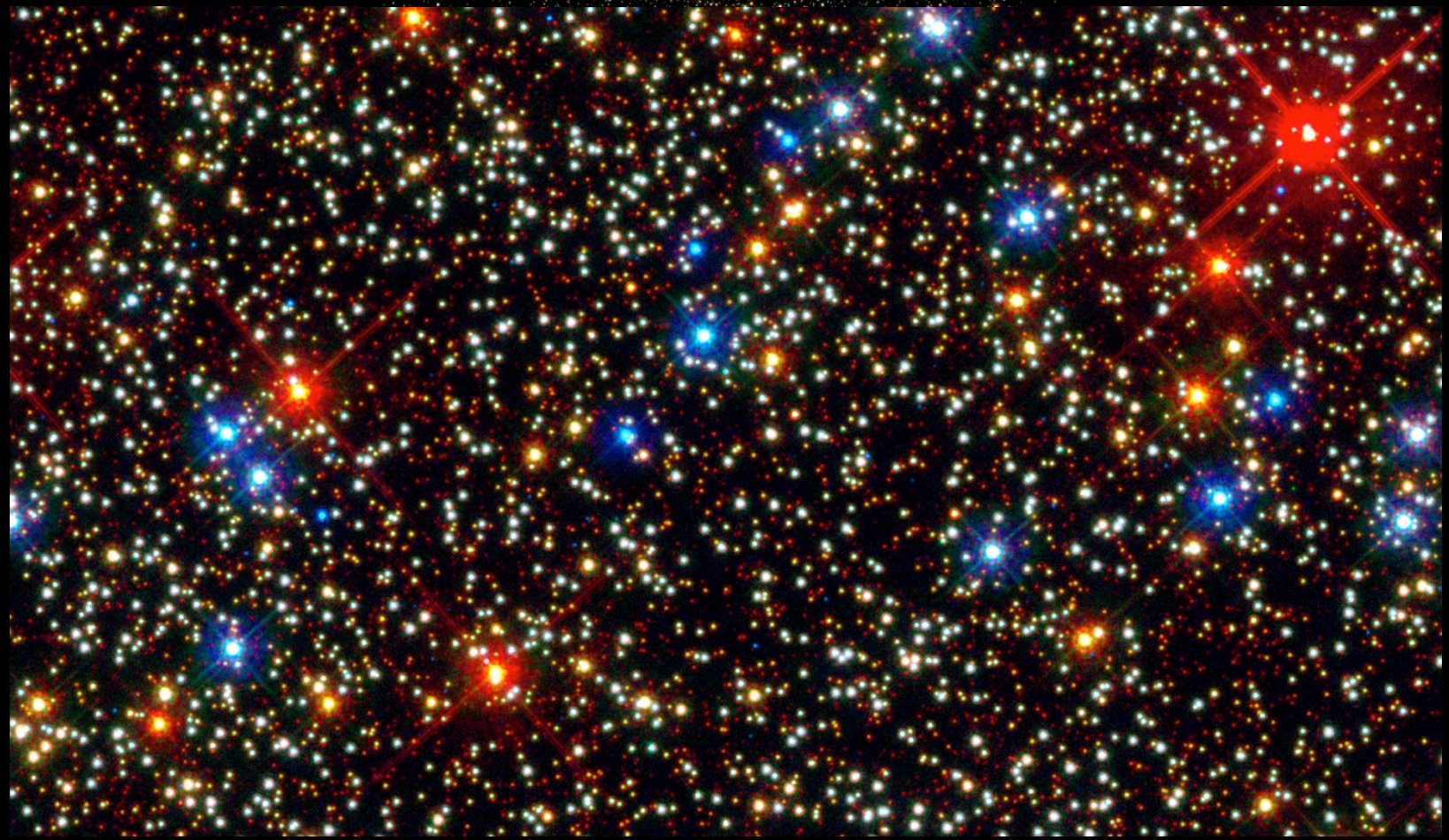
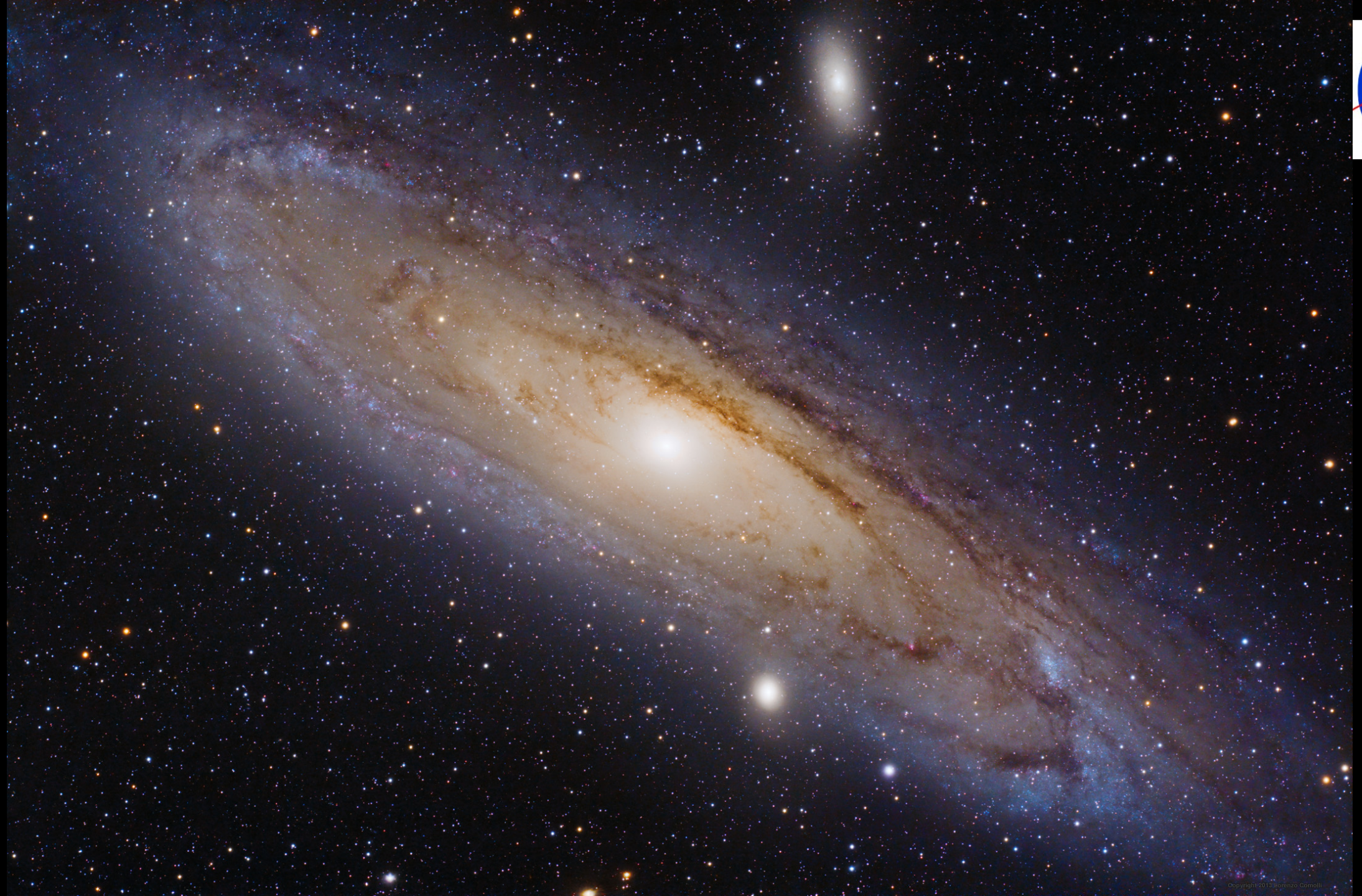
STIS/CCD G750M
NASA, ESA, and the Hubble SM4 ERO Team
STScI-PRC09-25i

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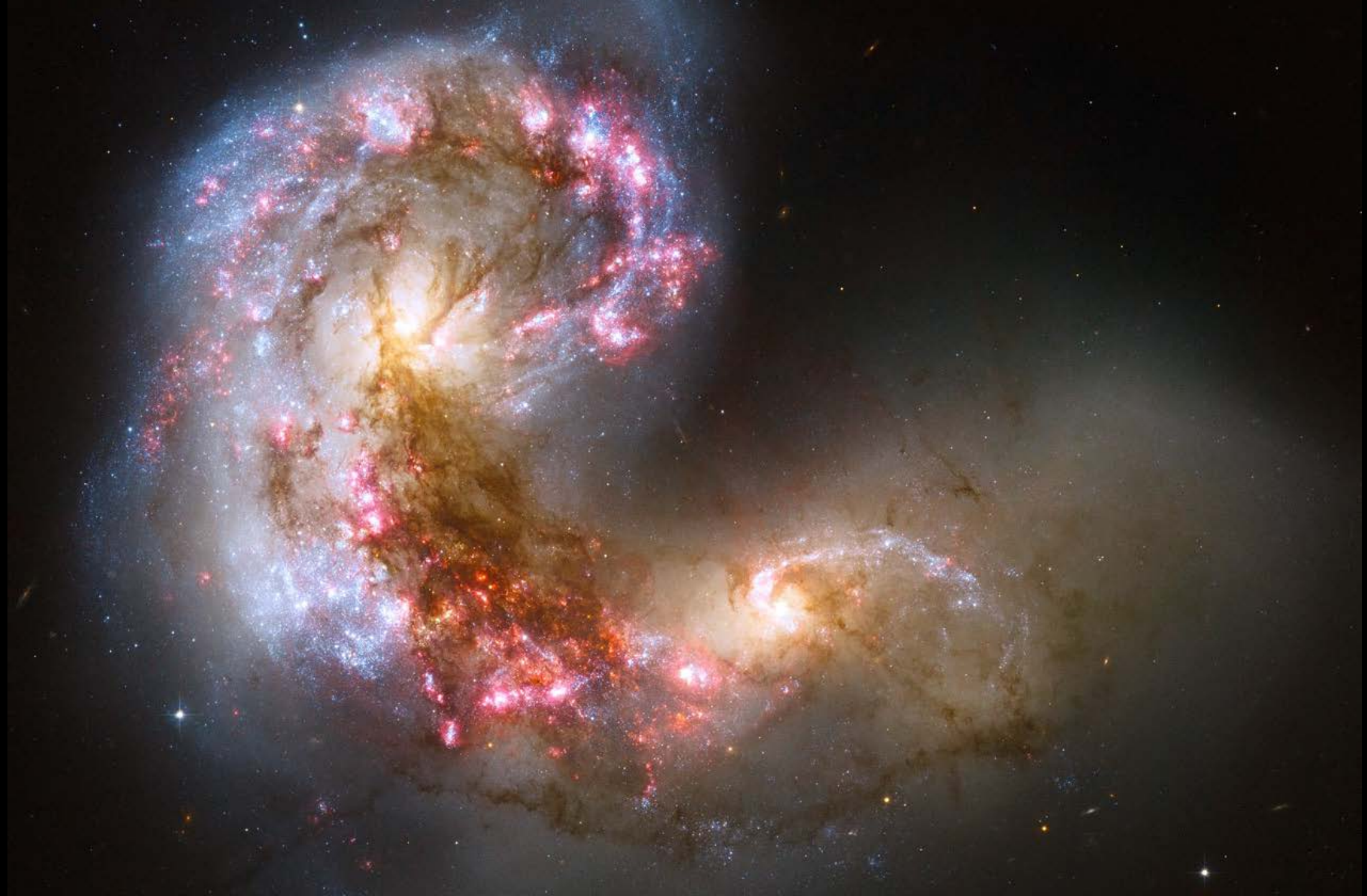
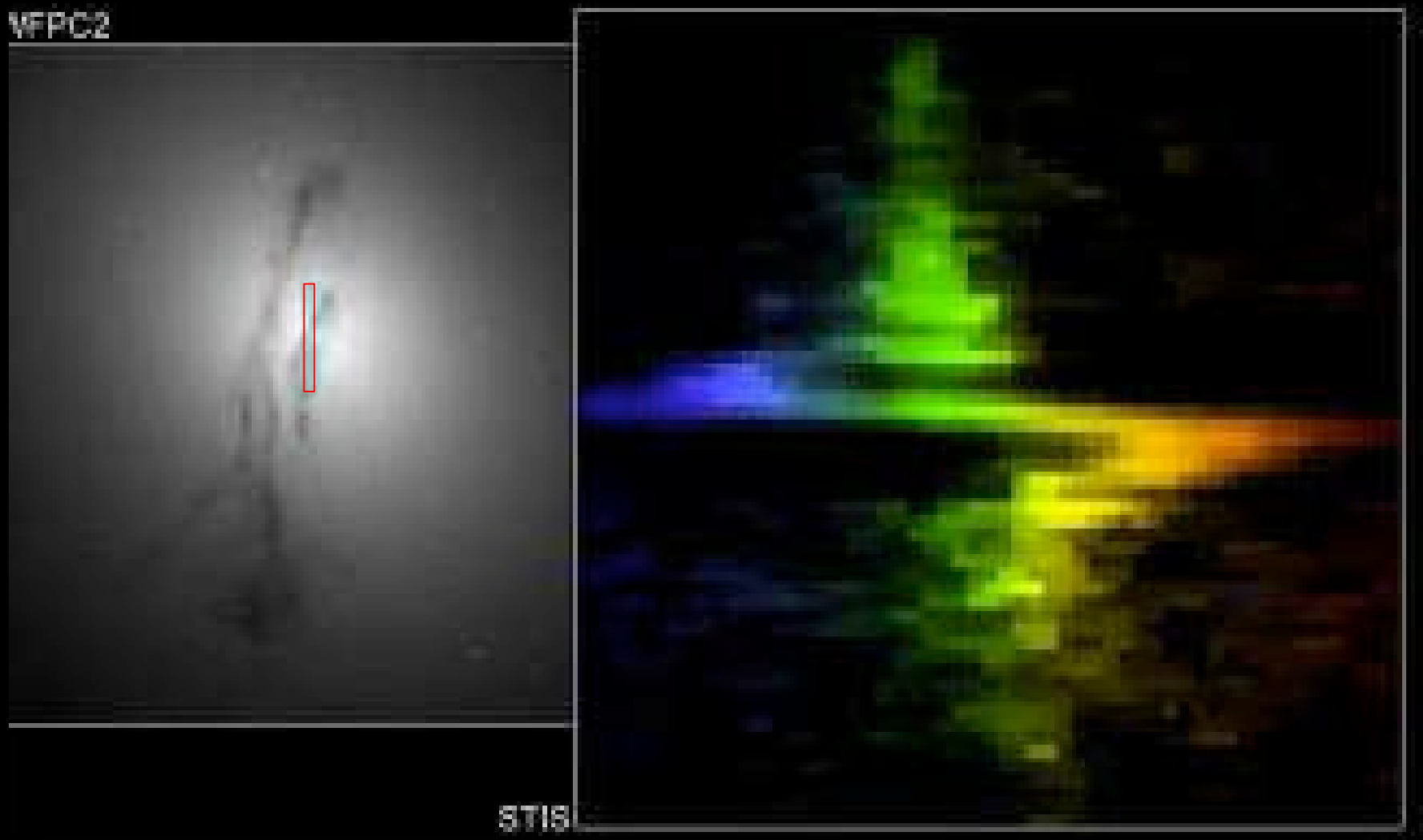
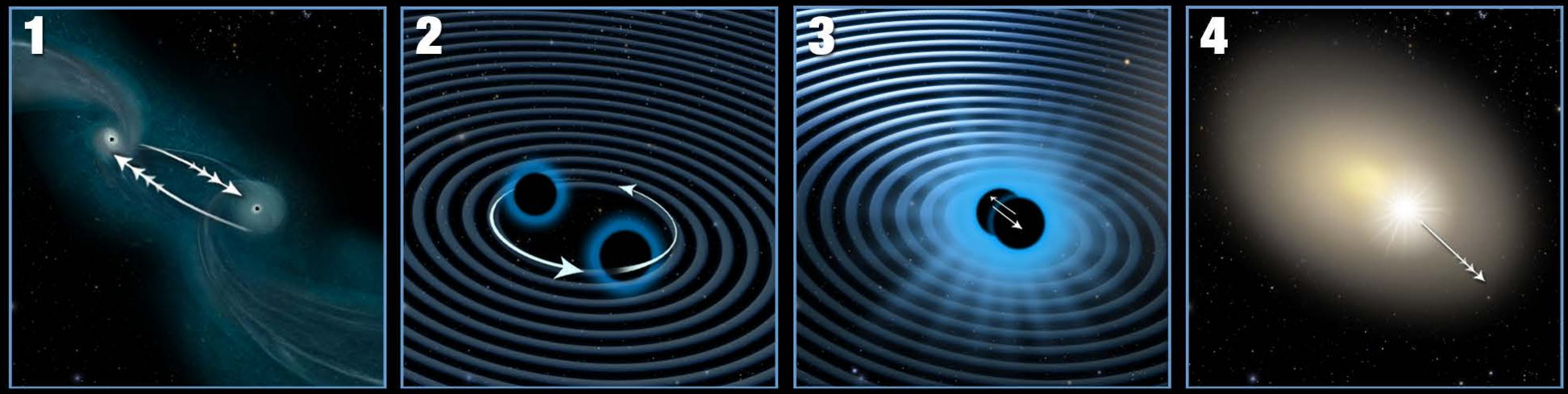


Massive Black Holes: Huge “Redshifts” near centers of Galaxies

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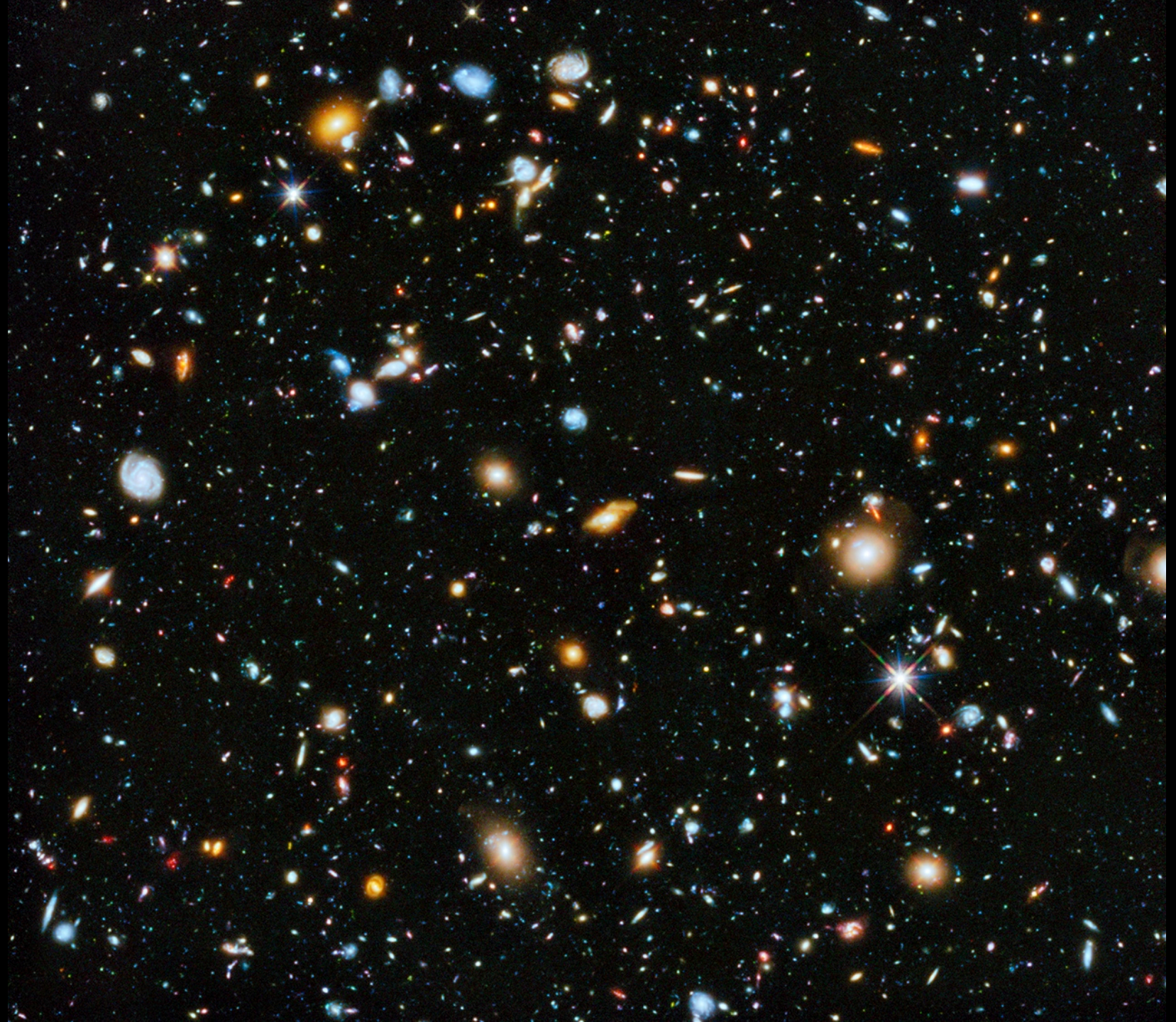


HUDF Including IR+UV

Galaxy Cluster Abell S1063
Hubble Frontier Fields

Hubble Space Telescope
ACS/WFC • WFC3/IR

NASA, ESA, and J. Lotz (STScI)

STScI-PRC16-28a

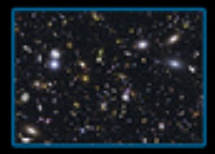
Hubble Probes the Early Universe

1990
Ground-based observatories

1995
Hubble Deep Field

2004
Hubble Ultra Deep Field

2010
Hubble Ultra Deep Field-IR



FUTURE
James Webb Space Telescope

Redshift (*z*):	Present	1	4	5	6	7	8	10	>20
Time after the Big Bang		6 billion years	1.5 billion years			800 million years		480 million years	200 million years

Page URLs, Acknowledgements

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- Acknowledgements
  - Ron Sheffield and Russ Werneth, various presentation materials
  - Ken Carpenter, HST Operations Project Scientist, for several key movies and slides on Hubble science